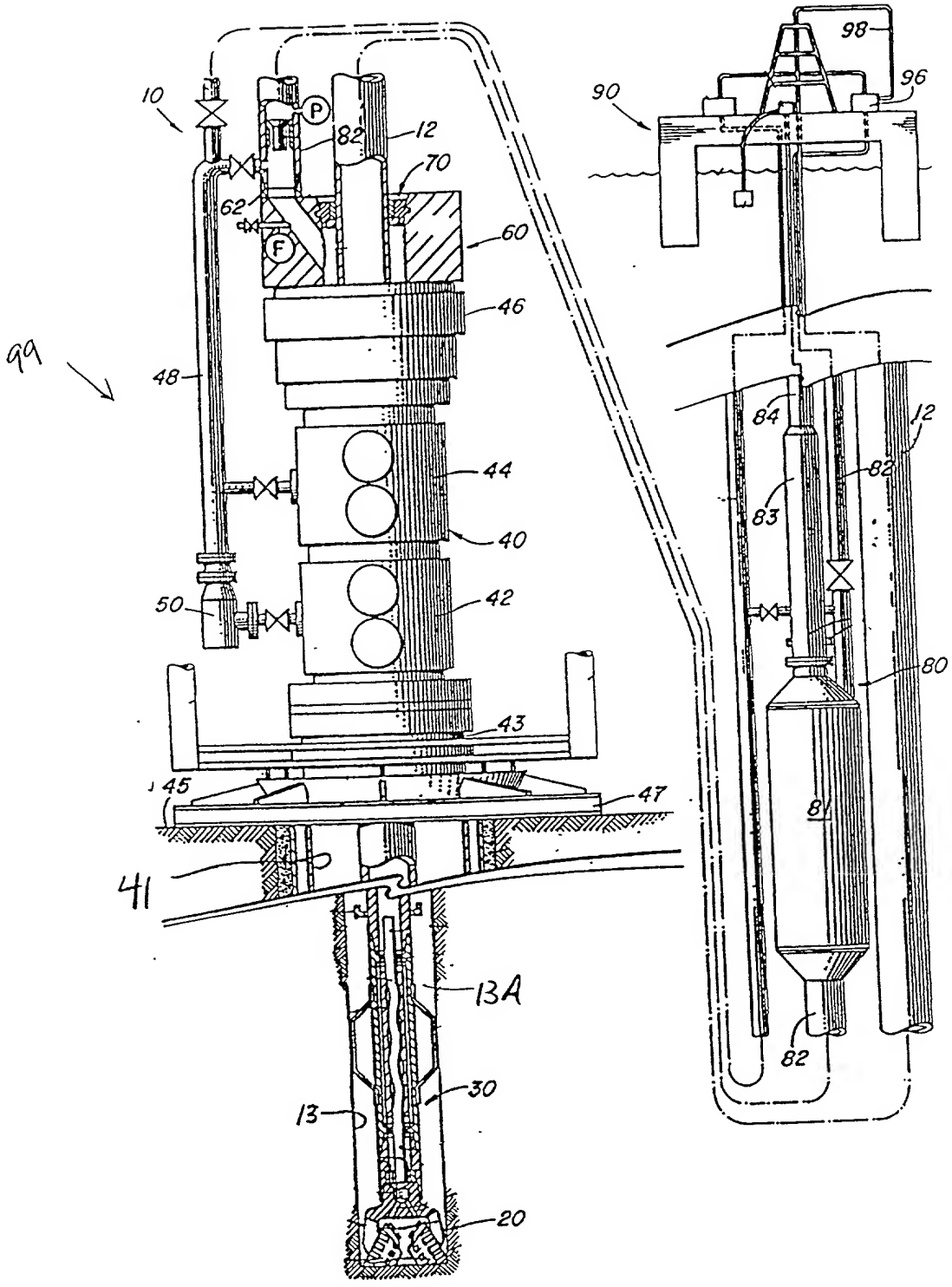

FIGURE 1 (PRIOR ART)

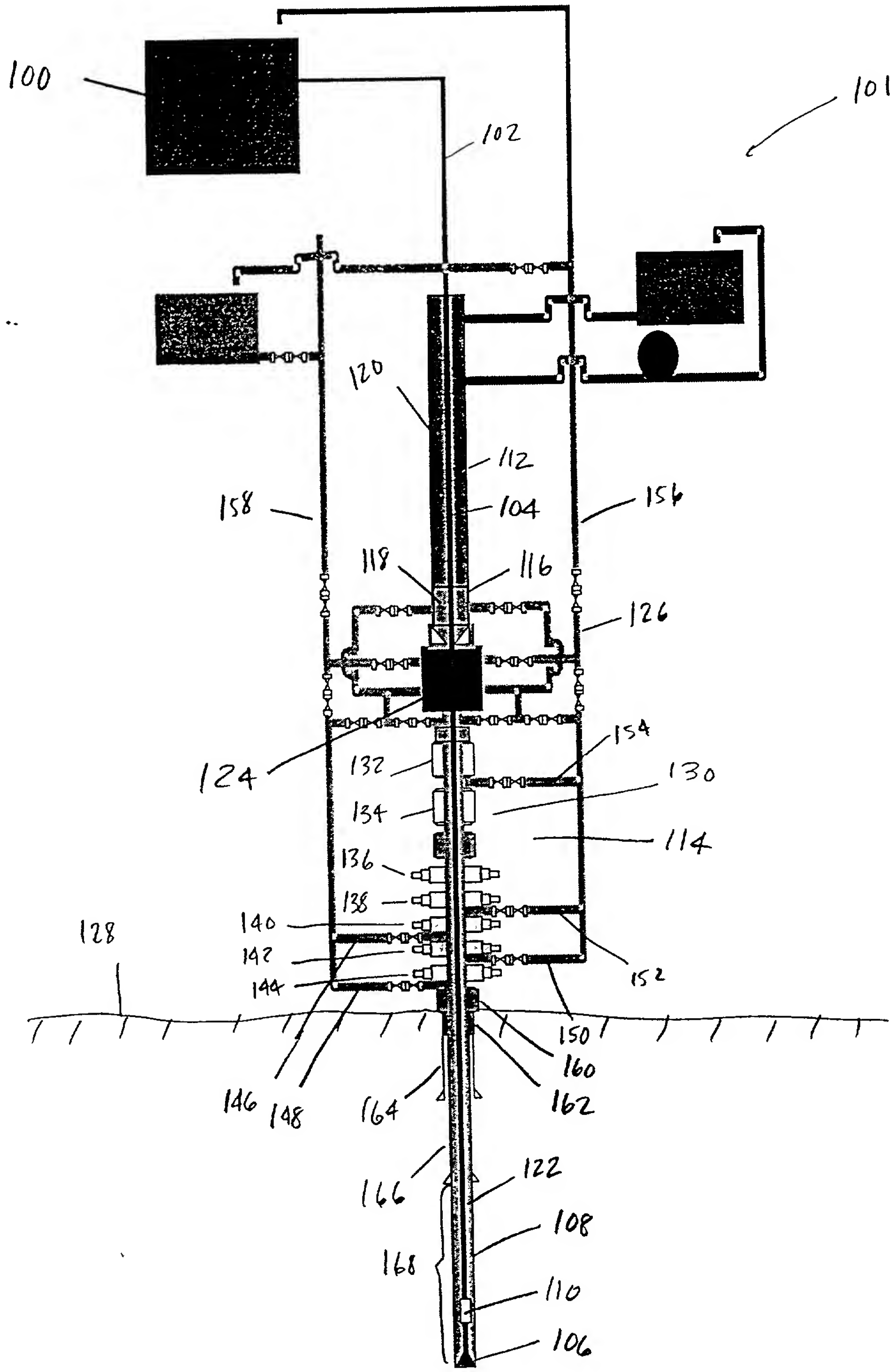

FIGURE 2

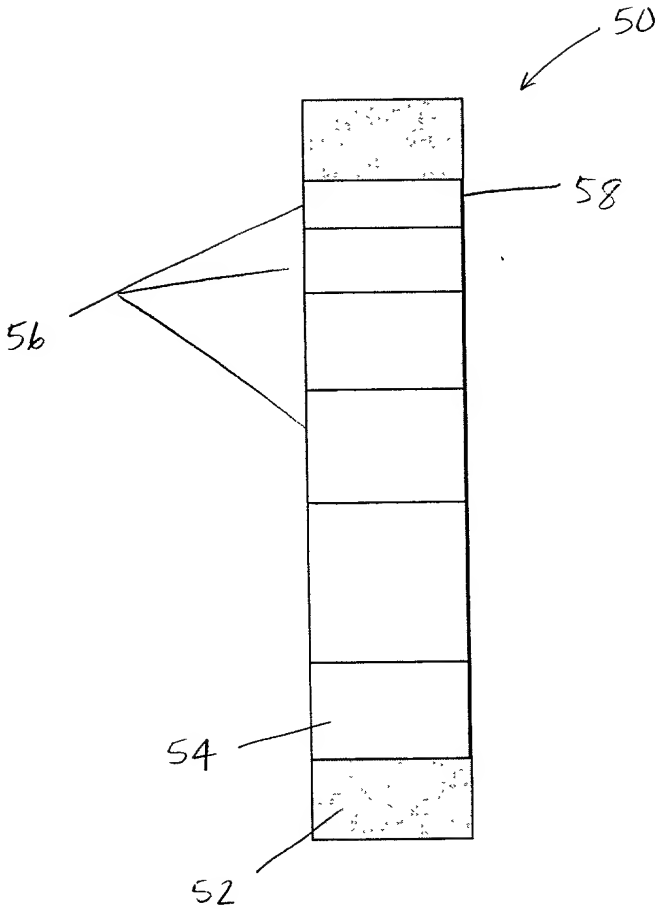

FIG 3

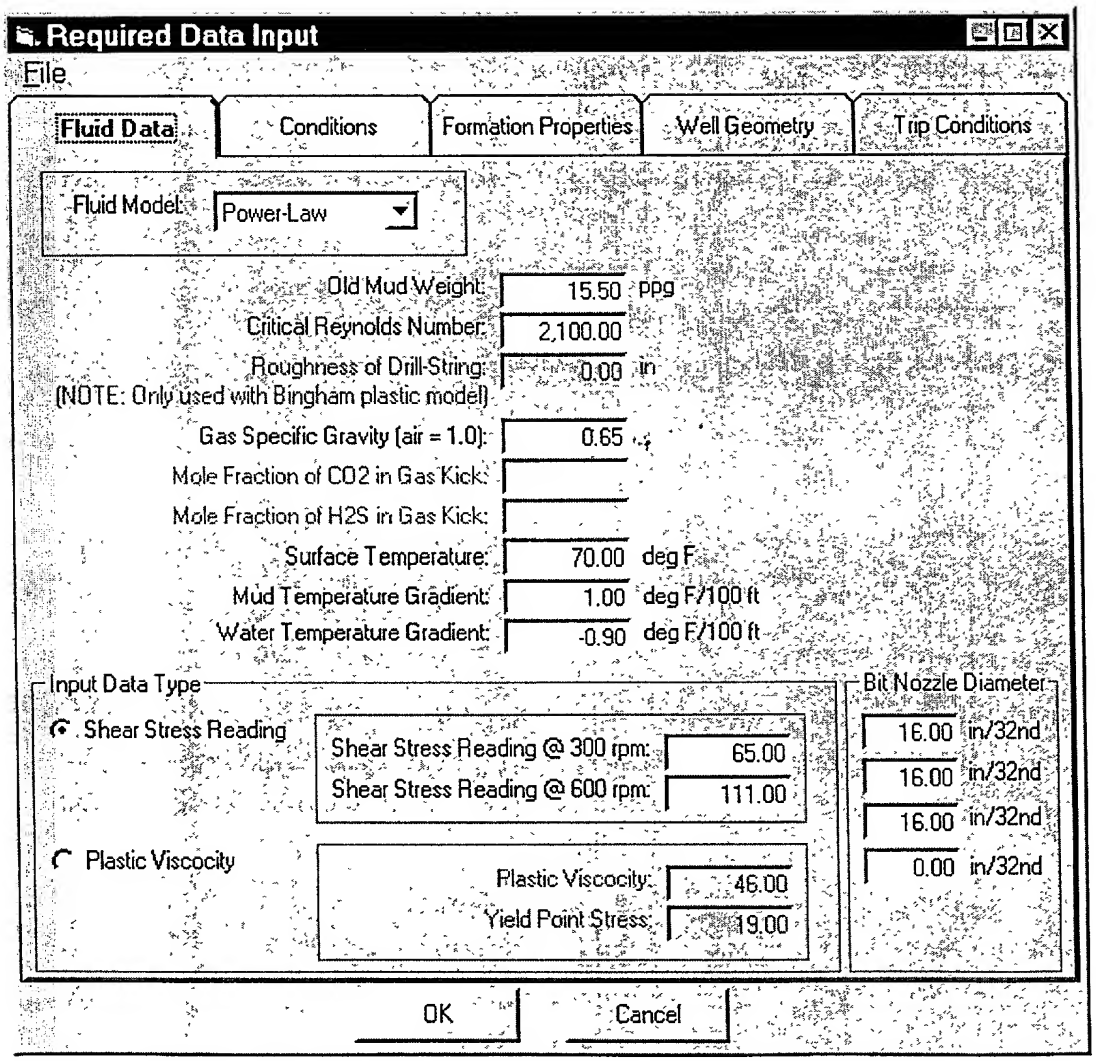

FIG. 4

Table 2 – Surface Tension of Water-Gas System

Pressure (psia)	Surface tension (dynes/cm) 74 °F	280 °F
0	75	53
1000	63	46
2000	59	40
3000	57	33
4000	54	26
5000	52	21
6000	52	21
7000	51	22
8000	50	23
9000	49	24

Fig 5

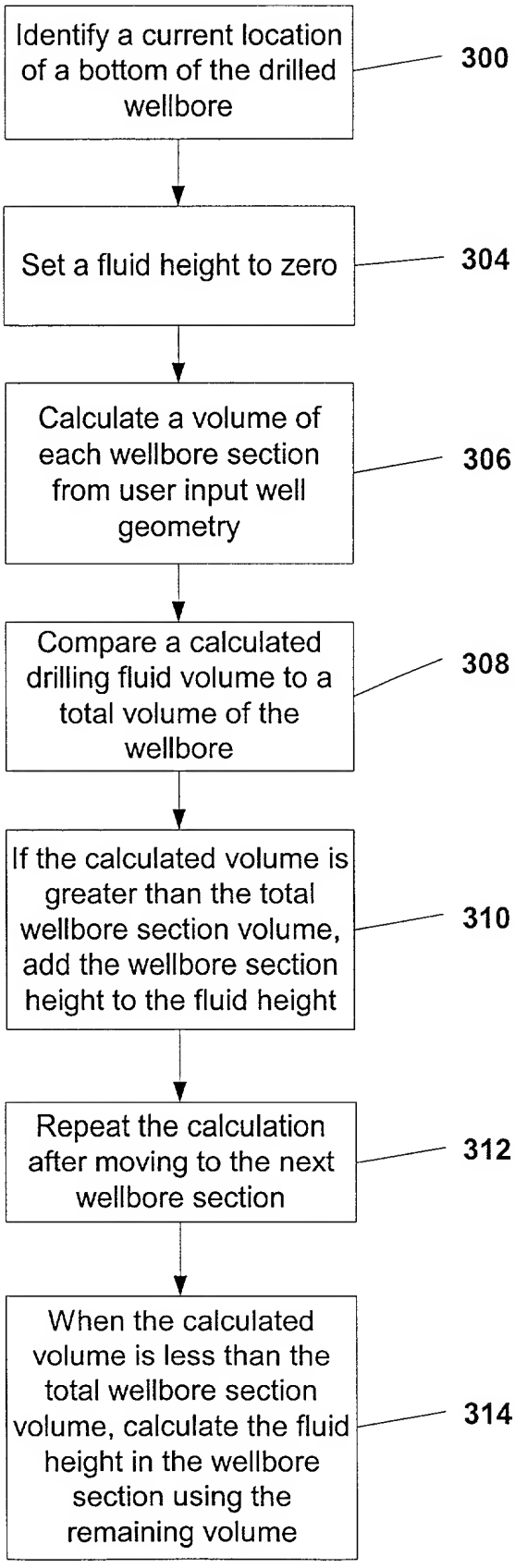

FIG. 6

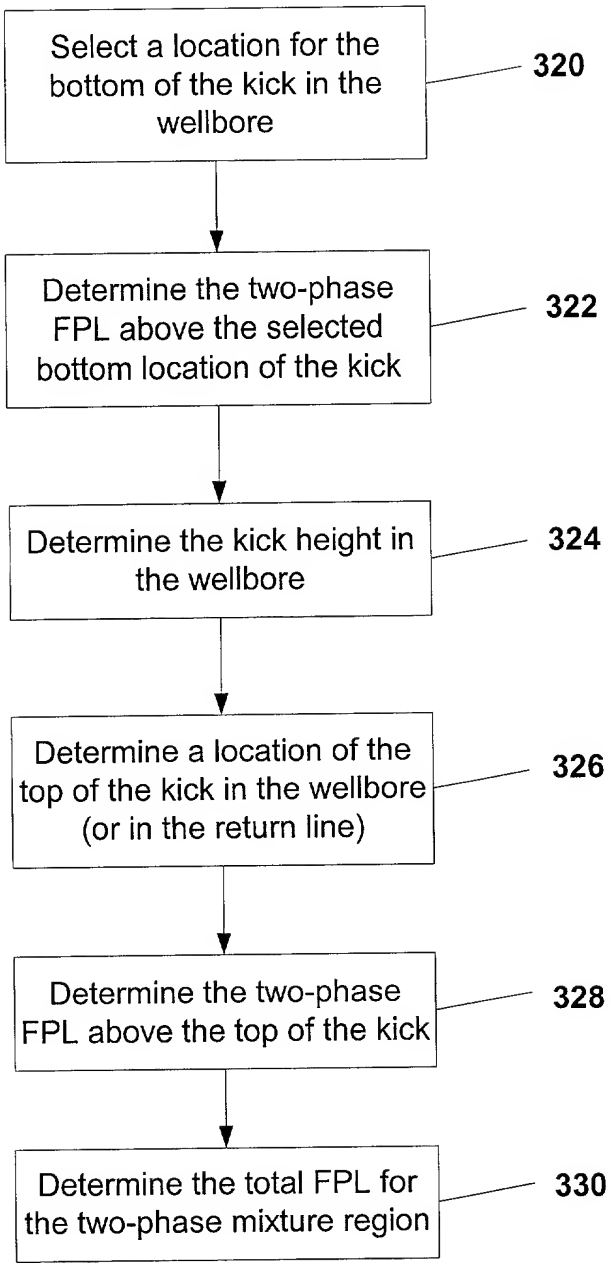
Select a location for the bottom of the kick in the wellbore
320
Determine the two-phase FPL above the selected bottom location of the kick
322
Determine the kick height in the wellbore
324
Determine a location of the top of the kick in the wellbore (or in the return line)
326
Determine the two-phase FPL above the top of the kick
328
Determine the total FPL for the two-phase mixture region
330

FIG. 7

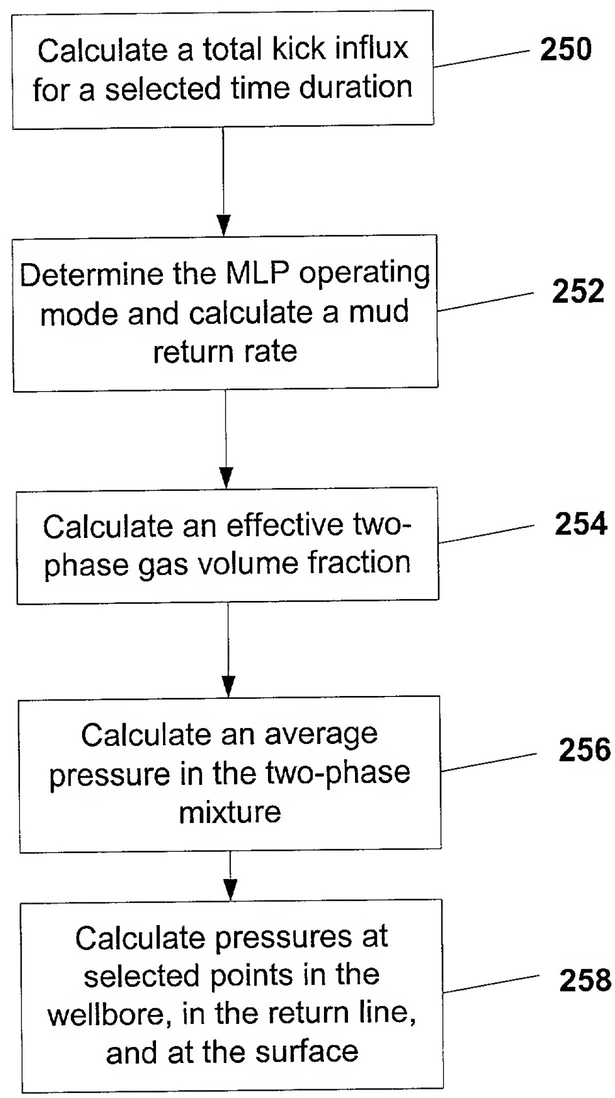

FIG. 8

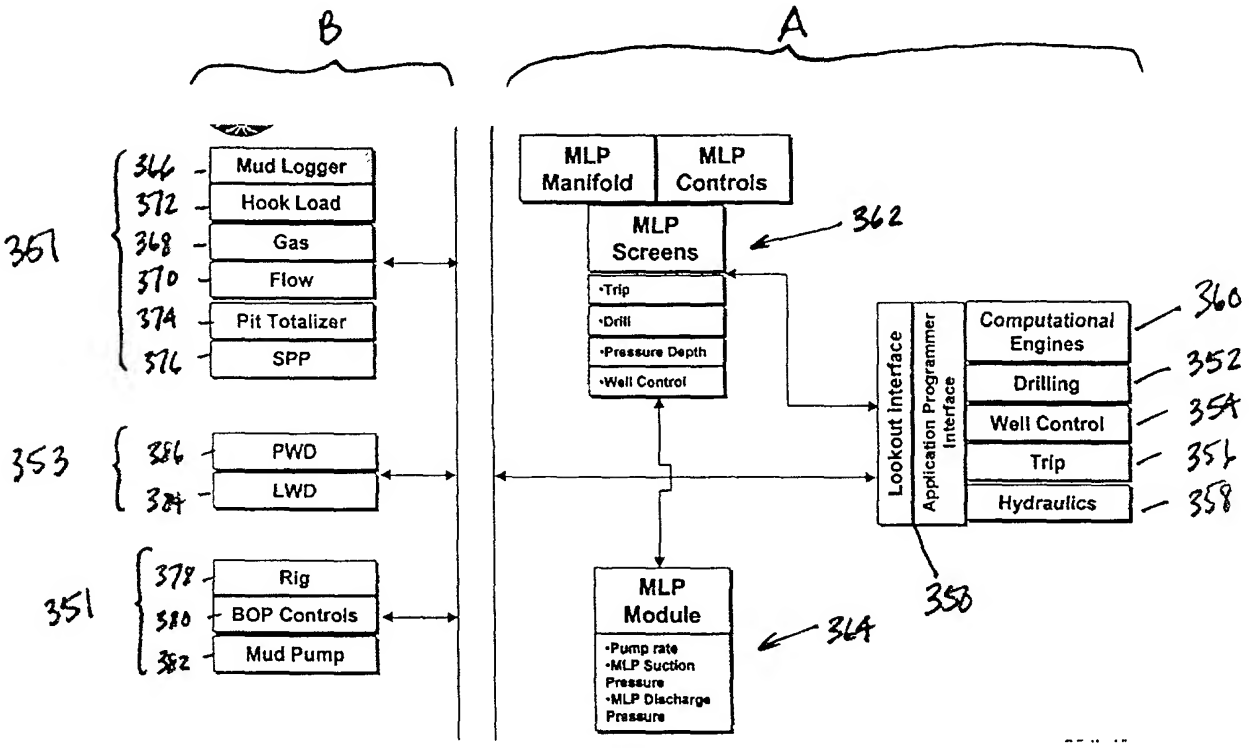
B
A
Mud Logger
Hook Load
Gas
Flow
Pit Totalizer
SPP
PWD
LWD
Rig
BOP Controls
Mud Pump
MLP Manifold
MLP Controls
MLP Screens
•Trip
•Drill
•Pressure Depth
•Well Control
MLP Module
•Pump rate
•MLP Suction Pressure
•MLP Discharge Pressure
Lookout Interface
Application Programmer Interface
Computational Engines
Drilling
Well Control
Trip
Hydraulics

FIG. 9

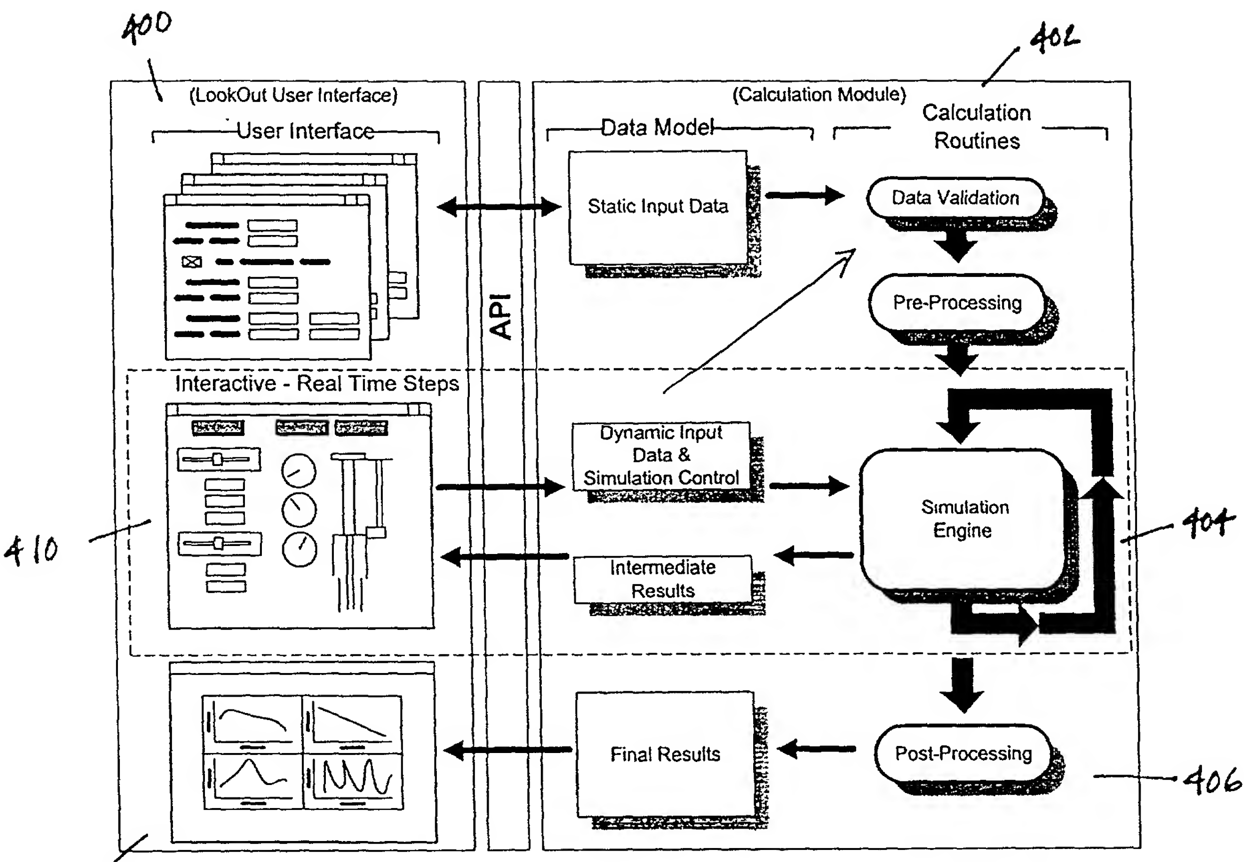
400
402
(LookOut User Interface)
User Interface
(Calculation Module)
Data Model
Calculation Routines
Static Input Data
Data Validation
Pre-Processing
API
Interactive - Real Time Steps
Dynamic Input Data & Simulation Control
Simulation Engine
Intermediate Results
410
404
Final Results
Post-Processing
406
408

FIG. 10

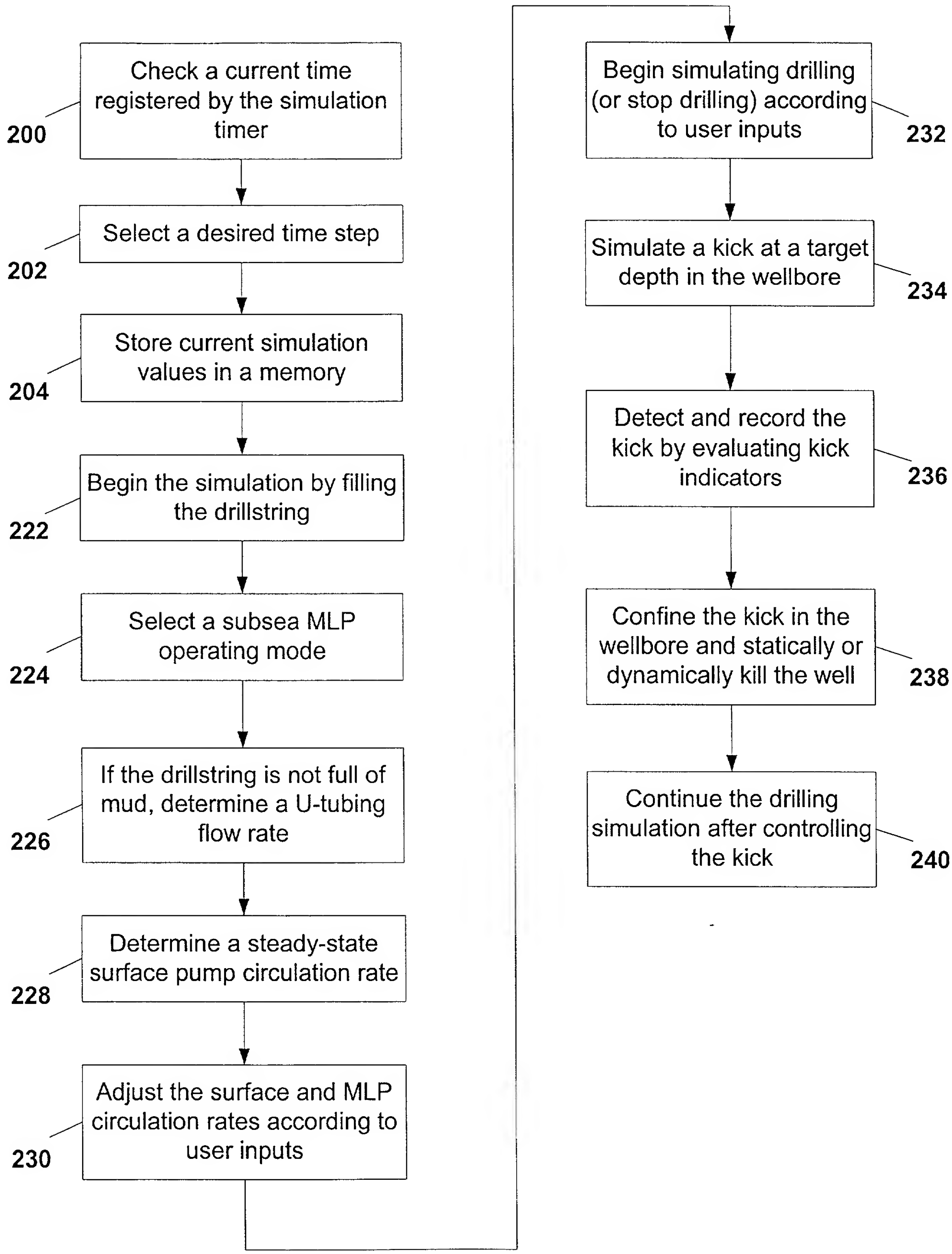
Check a current time registered by the simulation timer
200
Select a desired time step
202
Store current simulation values in a memory
204
Begin the simulation by filling the drillstring
222
Select a subsea MLP operating mode
224
If the drillstring is not full of mud, determine a U-tubing flow rate
226
Determine a steady-state surface pump circulation rate
228
Adjust the surface and MLP circulation rates according to user inputs
230
Begin simulating drilling (or stop drilling) according to user inputs
232
Simulate a kick at a target depth in the wellbore
234
Detect and record the kick by evaluating kick indicators
236
Confine the kick in the wellbore and statically or dynamically kill the well
238
Continue the drilling simulation after controlling the kick
240

FIG. 11

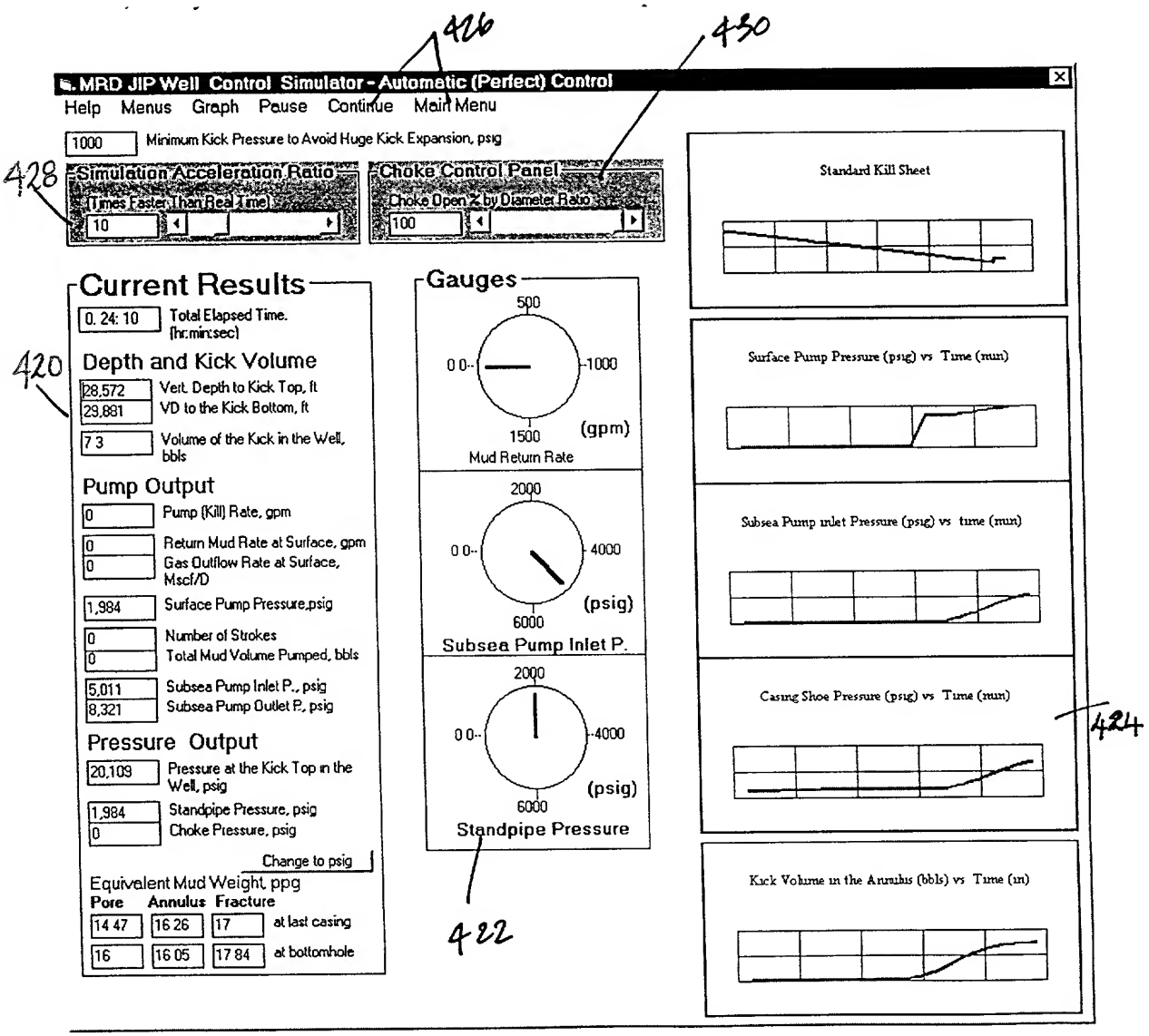
426
430
MRD JIP Well Control Simulator - Automatic (Perfect) Control
Help Menus Graph Pause Continue Main Menu
1000 Minimum Kick Pressure to Avoid Huge Kick Expansion, psig
428
Simulation Acceleration Ratio
Times Faster Than Real Time
10
Choke Control Panel
Choke Open % by Diameter Ratio
100
Current Results
0. 24: 10 Total Elapsed Time. (hr:min:sec)
420
Depth and Kick Volume
28,572 Vert. Depth to Kick Top, ft
29,881 VD to the Kick Bottom, ft
73 Volume of the Kick in the Well, bbls
Pump Output
0 Pump (Kill) Rate, gpm
0 Return Mud Rate at Surface, gpm
0 Gas Outflow Rate at Surface, Mscf/D
1,984 Surface Pump Pressure,psig
0 Number of Strokes
0 Total Mud Volume Pumped, bbls
5,011 Subsea Pump Inlet P., psig
8,321 Subsea Pump Outlet P., psig
Pressure Output
20,109 Pressure at the Kick Top in the Well, psig
1,984 Standpipe Pressure, psig
0 Choke Pressure, psig
Change to psig
Equivalent Mud Weight, ppg
Pore Annulus Fracture
14 47 16 26 17 at last casing
16 16 05 17 84 at bottomhole
Gauges
500
0 0
1000
1500
(gpm)
Mud Return Rate
2000
0 0
4000
6000
(psig)
Subsea Pump Inlet P.
2000
0 0
4000
6000
(psig)
Standpipe Pressure
422
Standard Kill Sheet
Surface Pump Pressure (psig) vs Time (min)
Subsea Pump inlet Pressure (psig) vs time (min)
Casing Shoe Pressure (psig) vs Time (min)
424
Kick Volume in the Annulus (bbls) vs Time (in)

FIG. 12

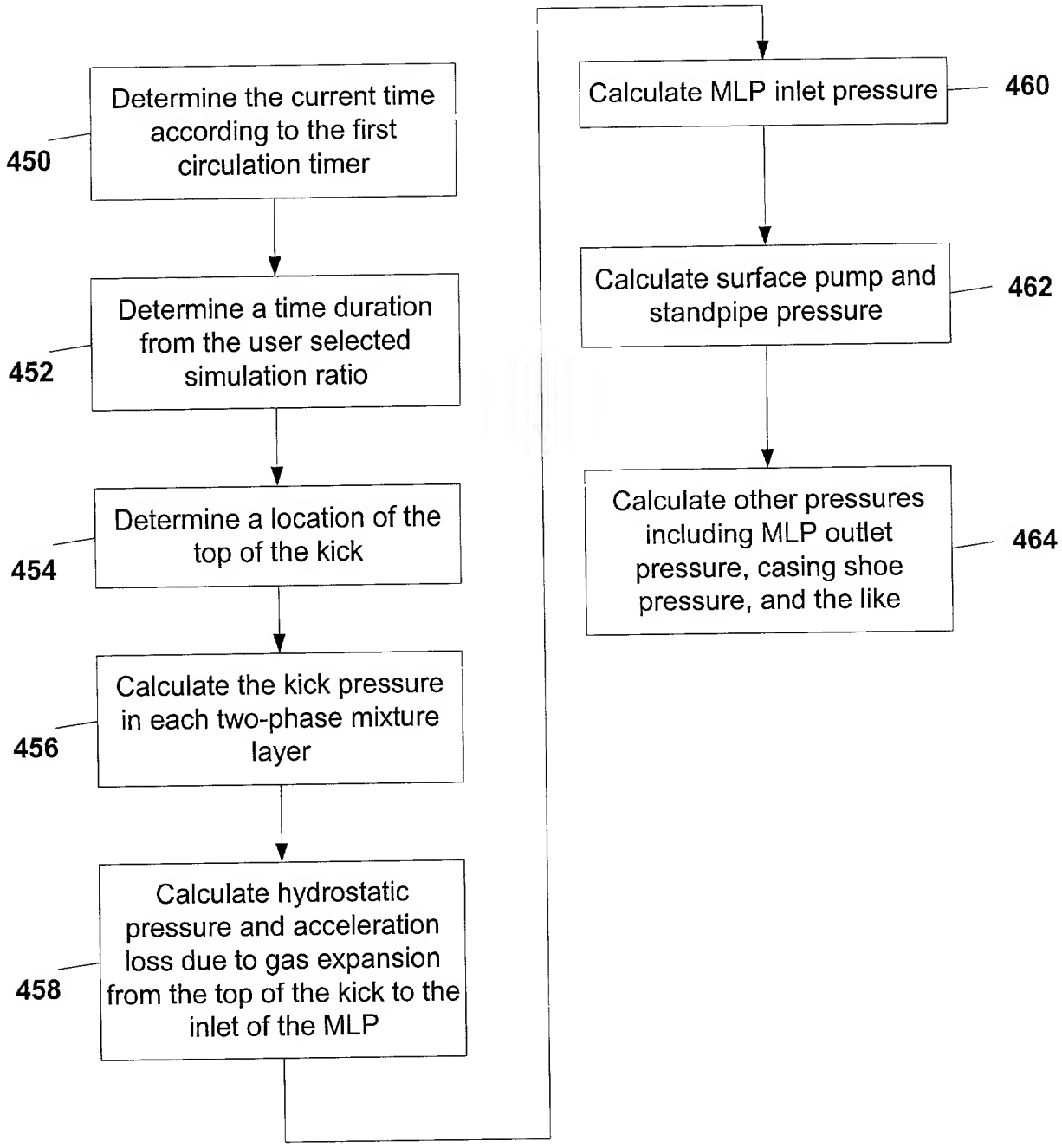
Determine the current time according to the first circulation timer
450
Determine a time duration from the user selected simulation ratio
452
Determine a location of the top of the kick
454
Calculate the kick pressure in each two-phase mixture layer
456
Calculate hydrostatic pressure and acceleration loss due to gas expansion from the top of the kick to the inlet of the MLP
458
Calculate MLP inlet pressure
460
Calculate surface pump and standpipe pressure
462
Calculate other pressures including MLP outlet pressure, casing shoe pressure, and the like
464

FIG. 13

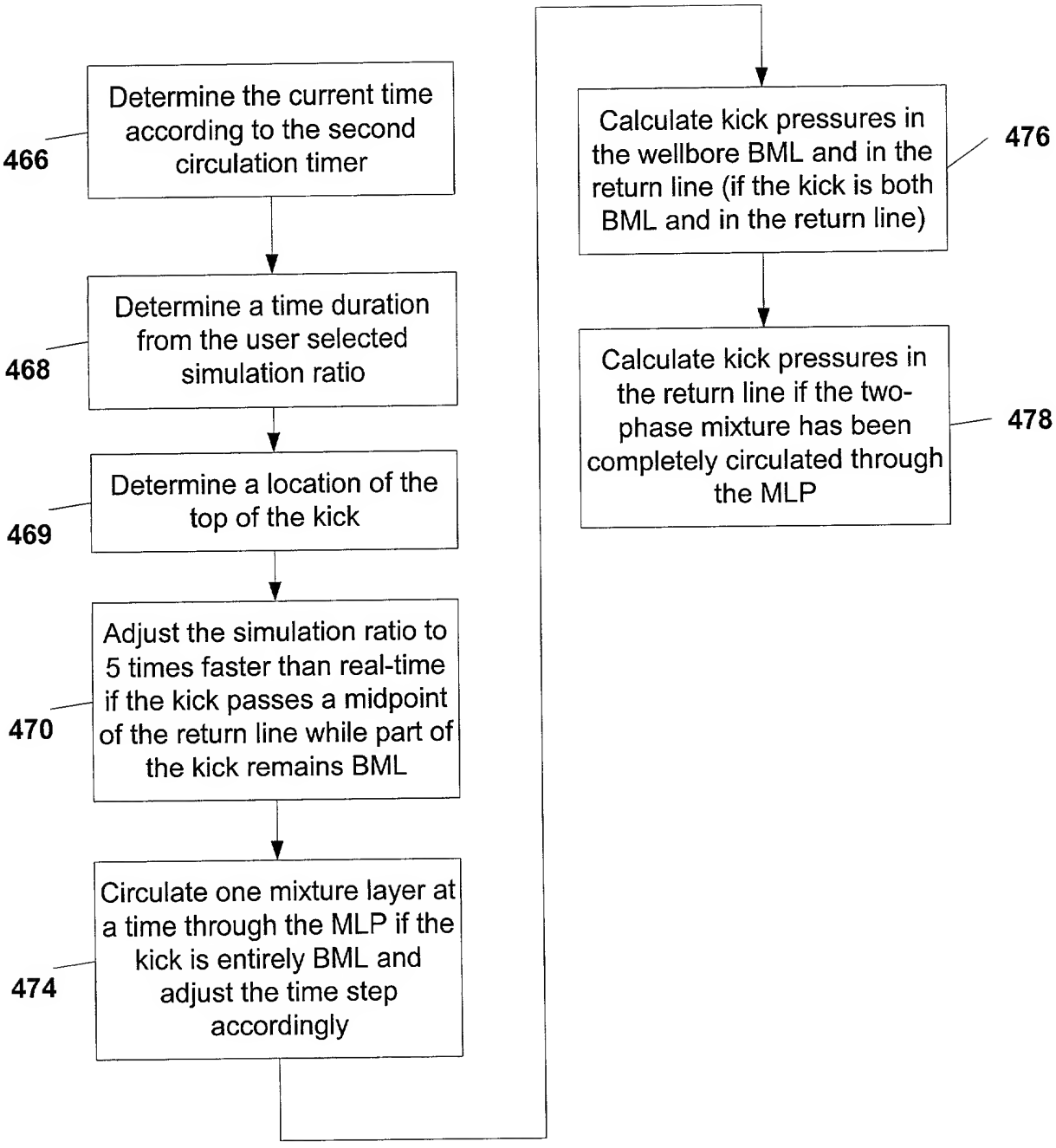
Determine the current time according to the second circulation timer
466
Determine a time duration from the user selected simulation ratio
468
Determine a location of the top of the kick
469
Adjust the simulation ratio to 5 times faster than real-time if the kick passes a midpoint of the return line while part of the kick remains BML
470
Circulate one mixture layer at a time through the MLP if the kick is entirely BML and adjust the time step accordingly
474
Calculate kick pressures in the wellbore BML and in the return line (if the kick is both BML and in the return line)
476
Calculate kick pressures in the return line if the two-phase mixture has been completely circulated through the MLP
478

FIG. 14

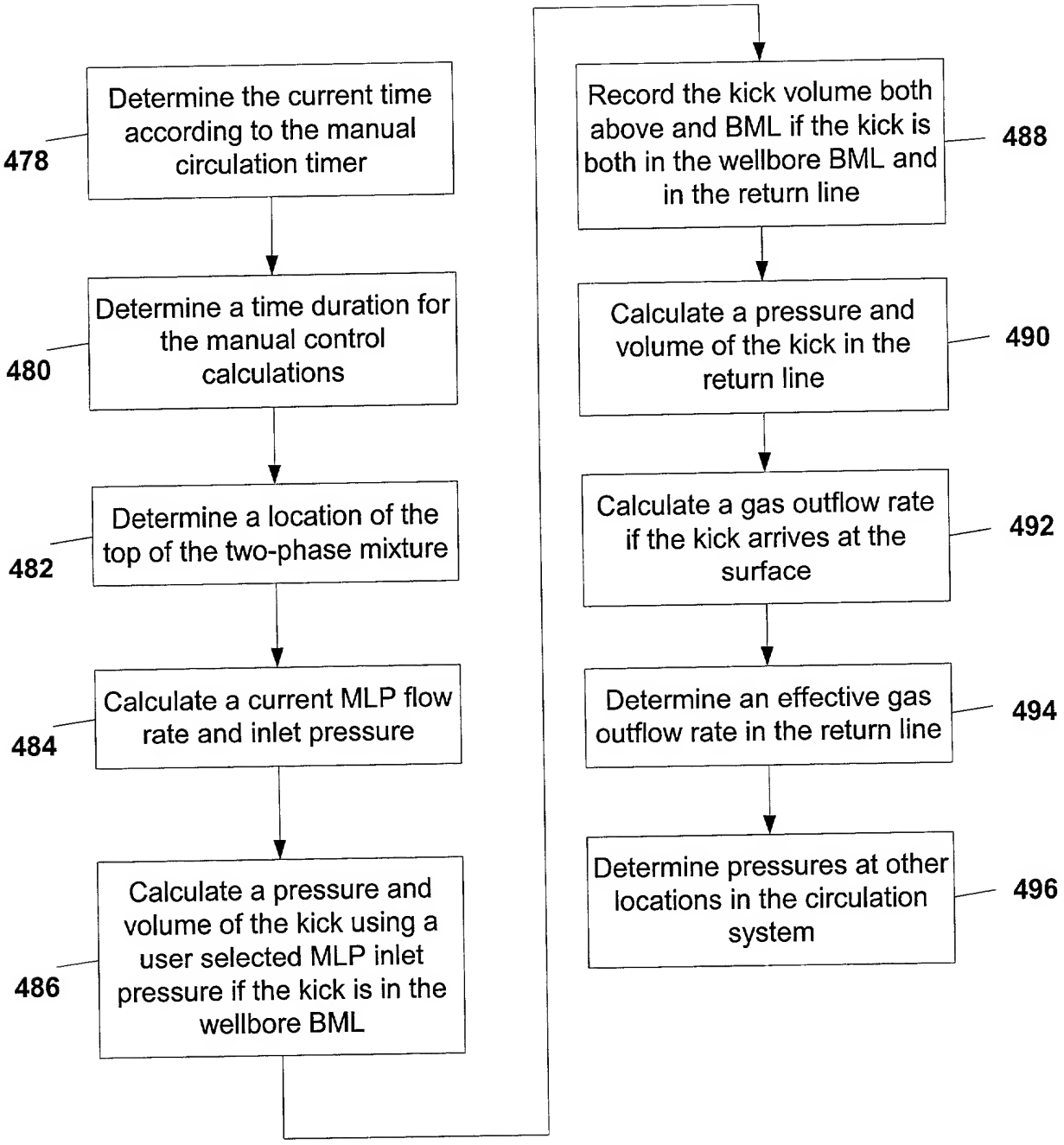
Determine the current time according to the manual circulation timer
478
Determine a time duration for the manual control calculations
480
Determine a location of the top of the two-phase mixture
482
Calculate a current MLP flow rate and inlet pressure
484
Calculate a pressure and volume of the kick using a user selected MLP inlet pressure if the kick is in the wellbore BML
486
Record the kick volume both above and BML if the kick is both in the wellbore BML and in the return line
488
Calculate a pressure and volume of the kick in the return line
490
Calculate a gas outflow rate if the kick arrives at the surface
492
Determine an effective gas outflow rate in the return line
494
Determine pressures at other locations in the circulation system
496

FIG. 15